CHAPTER 5

FLUID LINES AND FITTINGS

GENERAL

The term "aircraft plumbing" refers not only to the hose, tubing, fittings, and connectors used in the aircraft, but also to the processes of forming and installing them.

Occasionally it may be necessary to repair or replace damaged aircraft plumbing lines. Very often the repair can be made simply by replacing the tubing. However, if replacements are not available, the needed parts may have to be fabricated. Replacement tubing should be of the same size and material as the original line. All tubing is pressure tested prior to initial installation, and is designed to withstand several times the normal operating pressure to which it will be subjected. If a tube bursts or cracks, it is generally the result of excessive vibration, improper installation, or damage caused by collision with an object. All tubing failures should be carefully studied and the cause of the failure determined.

PLUMBING LINES

Aircraft plumbing lines usually are made of metal tubing and fittings or of flexible hose. Metal tubing is widely used in aircraft for fuel, oil, coolant, oxygen, instrument, and hydraulic lines. Flexible hose is generally used with moving parts or where the hose is subject to considerable vibration.

Generally, aluminum alloy or corrosion-resistant steel tubing have replaced copper tubing. The high fatigue factor of copper tubing is the chief reason for its replacement. It becomes hard and brittle from vibration and finally breaks, however it may be restored to its soft annealed state by heating it red hot and quenching it in cold water. Cooling in air will result in a degree of softness but not equal to that obtained with the cold water quench. This annealing process must be accomplished if copper tubing is removed for any reason. Inspection of copper tubing for cracks, hardness, brittleness and general condition should be accomplished at regular intervals to preclude failure. The workability, resistance to corrosion, and lightweight of aluminum alloy are major factors in its adoption for aircraft plumbing.

In some special high-pressure (3,000 p.s.i.) hydraulic installations, corrosion-resistant steel tubing, either annealed or 1/4-hard, is used. Corrosion-resistant steel tubing does not have to be annealed for flaring or forming; in fact, the flared section is somewhat strengthened by the cold working and strain hardening during the flaring process. Its higher tensile strength permits the use of tubing with thinner walls;

consequently the final installation weight is not much greater than that of the ticker-wall aluminum alloy tubing.

IDENTIFICATION OF MATERIALS

Before making repairs to any aircraft plumbing, it is important to make accurate identification of plumbing materials. Aluminum alloy or steel tubing can be identified readily by sight where it is used as the basic plumbing material. However, it is difficult to determine whether a material is carbon steel or stainless steel, or whether it is 1100, 3003, 5052-0, or 2024-T aluminum alloy.

It may be necessary to test samples of the material for hardness by filing or scratching with a scriber. The magnet test is the simplest method for distinguishing between the annealed austenitic and the ferritic stainless steels. The austenitic types are nonmagnetic unless heavily cold worked, whereas the straight chromium carbon and low alloy steels are strongly magnetic.

Figure below gives the methods for identifying five common metallic materials by using the magnet and concentrated nitric acid tests.

Material	**Magnet test**	**Nitric acid test**
Carbon steel	**Strongly magnetic.**	**Slow chemical action, brown.**
18-8	**Nonmagnetic.**	**No action.**
Pure nickel	**Strongly magnetic.**	**Slow action, pale green.**
Monel	**Slightly magnetic.**	**Rapid action, greenish blue.**
Nickel steel	**Nonmagnetic.**	**Rapid action, greenish blue.**

Figure 5-1. Identification of metallic materials.

By comparing code markings of the replacement tubing with the original markings on the tubing being replaced, it is possible to identify definitely the material used in the original installation.

The alloy designation is stamped on the surface of large aluminum alloy tubing. On small aluminum alloy tubing, the designation may be stamped on the surface, but more often it is shown by a color code. Bands of the color code, not more than 4 inches in width, are painted at the two ends and approximately midway between the ends of some tubing. When the band consists of two colors, one-half the width is used for each color.

Painted color codes used to identify aluminum alloy tubing are:

Aluminum alloy number	Color of band
1100	White
3003	Green
2014	Gray
2024	Red
5052	Purple
6053	Black
6061	Blue and Yellow
7075	Brown and Yellow

Aluminum alloy tubing, 1100 (1/2-hard) or 3003 (1/2-hard), is used for general purpose lines of low or negligible fluid pressures, such as instrument lines and ventilating conduits. The 2024-T and 5052-0 aluminum alloy materials are used in general purpose systems of low and medium pressures, such as hydraulic and pneumatic 1,000 to 1,500 p.s.i. systems and fuel and oil lines. Occasionally, these materials are used in high-pressure (3,000 p.s.i.) systems.

Tubing made from 2024-T and 5052-0 materials will withstand a fairly high pressure before bursting. These materials are easily flared and are soft enough to be formed with handtools. They must be handled with care to prevent scratches, dents, and nicks.

Corrosion-resistant steel tubing, either annealed or 1/4-hard, is used extensively in high-pressure hydraulic systems for the operation of landing gear, flaps, brakes, and the like. External brake lines should always be made of corrosion-resistant steel to minimize damage from rocks thrown by the tires during takeoff and landing, and from careless ground handling. Although identification markings for steel tubing differ, each usually includes the manufacturer's name or trademark, the SAE number, and the physical condition of the metal.

Metal tubing is sized by outside diameter, which is measured fractionally in sixteenths of an inch. Thus Number 6 tubing is 6/16 (or 3/8 inch) and Number 8 tubing is 8/16 (or 1/2 inch), etc.

In addition to other classification or means of identification, tubing is manufactured in various wall thicknesses. Thus, it is important when installing tubing to know not only the material and outside diameter, but also the thickness of the wall.

FLEXIBLE HOSE

Flexible hose is used in aircraft plumbing to connect moving parts with stationary parts in locations subject to vibration or where a great amount of flexibility is needed. It can also serve as a connector in metal tubing systems.

Synthetics

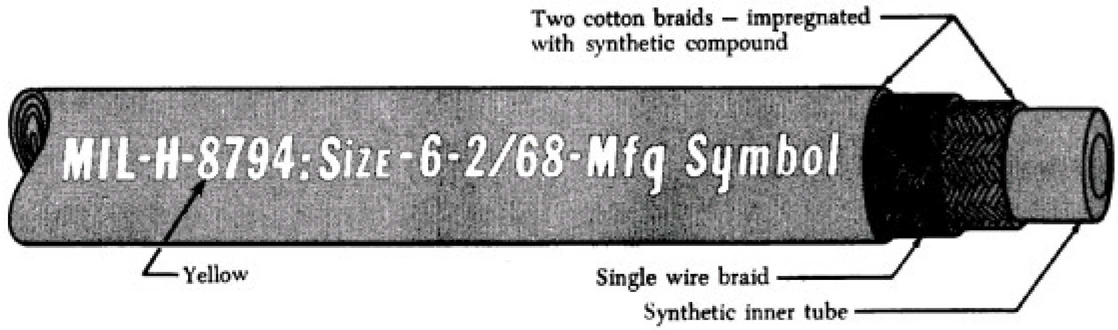
Synthetic materials most commonly used in the manufacture of flexible hose are: Buna-N, Neoprene, Butyl and Teflon (trademark of DuPont Corp.). Buna-N is a synthetic rubber compound which has excellent resistance to petroleum products. Do not confuse with Buna-S. Do not use for phosphate ester base hydraulic fluid (Skydrol (Registered Trademark)). Neoprene is a synthetic rubber compound which has an acetylene base. Its resistance to petroleum products is not as good as Buna-N but has better abrasive resistance. Do not use for phosphate ester base hydraulic fluid (Skydrol (Registered Trademark)). Butyl is a synthetic rubber compound made from petroleum raw materials. It is an excellent material to use with phosphate ester based hydraulic fluid (Skydrol (Registered Trademark)). Do not use with petroleum products. Teflon is the DuPont trade name for tetrafluoroethylene resin. It has a broad operating temperature range (-65 degrees F. to +450 degrees F.). It is compatible with nearly every substance or agent used. It offers little resistance to flow; sticky viscous materials will not adhere to it. It has less volumetric expansion than rubber and the shelf and service life is practically limitless.

Rubber Hose

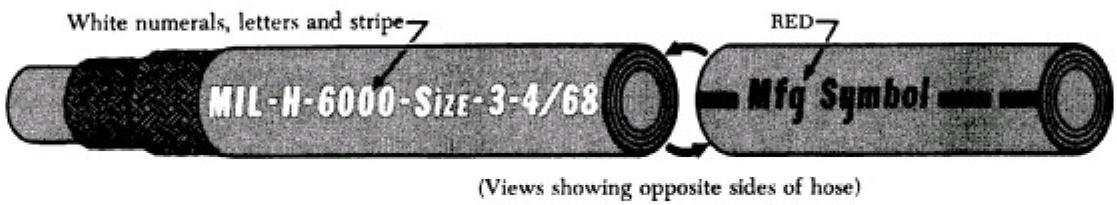
Flexible rubber hose consists of a seamless synthetic rubber inner tube covered with layers of cotton braid and wire braid, and an outer layer of rubber-impregnated cotton braid. This type of hose is suitable for use in fuel, oil, coolant, and hydraulic systems. The types of hose are normally classified by the amount of pressure they are designed to withstand under normal operating conditions.

1. Low pressure, any pressure below 250 p.s.i. Fabric braid reinforcement.
2. Medium pressure, pressure up to 3,000 p.s.i.
    - One wire braid reinforcement.
    - Smaller sizes carry pressure up to 3,000 p.s.i.
    - Larger sizes carry pressure up to 1,500 p.s.i.
3. High pressure (all sizes up to 3,000 p.s.i. operating pressures).

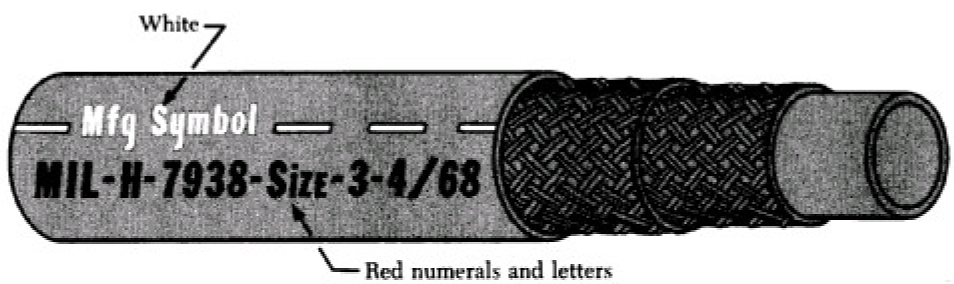
Identification markings consisting of lines, letters, and numbers are printed on the hose. (See figure 5-2.) These code markings show such information as hose size, manufacturer, date of manufacture, and pressure and temperature limits. Code markings assist in replacing a hose with one of the same specification or a recommended substitute. Hose suitable for use with phosphate ester base hydraulic fluid will be marked "Skydrol (Registered Trademark) use". In some instances several types of hose may be suitable for the same use. Therefore, in order to make the correct hose selection, always refer to the maintenance or parts manual for the particular airplane.



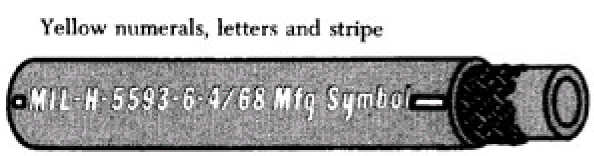
A. Flame- and aromatic-resistant hose



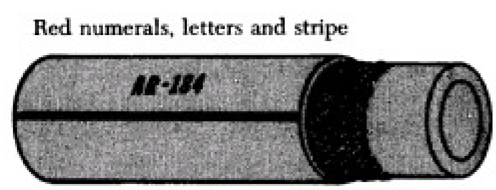
B. Nonself-sealing, Aromatic and Heat-resistant hose



C. Flame-, Aromatic-, and Oil-resistant hose



D. Nonself-sealing, Aromatic-resistant hose.



E. Self-sealing, Aromatic-resistant hose

FIGURE 5–2. Hose identification markings.

Teflon Hose

Teflon hose is a flexible hose designed to meet the requirements of higher operating temperatures and pressures in present aircraft systems. It can generally be used in the same manner as rubber hose. Teflon hose is processed and extruded into tube shape to a desired size. It is covered with stainless steel wire, which is braided over the tube for strength and protection.

Teflon hose is unaffected by any known fuel, petroleum, or synthetic base oils, alcohol, coolants, or solvents commonly used in aircraft. Although it is highly resistant to vibration and fatigue, the principle advantage of this hose it its operating strength.

Size Designation

The size of flexible hose is determined by its inside diameter. Sizes are in one-sixteenth-inch increments and are identical to corresponding sizes of rigid tubing, with which it can be used.

Identification of Fluid Lines

Fluid lines in aircraft are often identified by markers made up of color codes, words and geometric symbols. These markers identify each line's function, content, and primary hazard, as well as the direction of fluid flow. Figure 5-3 illustrates the various color codes and symbols used to designate the type of system and its contents.

In most instances, fluid lines are marked with 1-inch tape or decals, as shown in figure 5-4(A). On lines 4 inches in diameter (or larger), lines in oily environment, hot lines, and on some cold lines, steel tags may be used in place of tape of decals, as shown in figure 5-4(B). Paint is used on lines in engine compartments, where there is the possibility of tapes, decals, or tags being drawn into the engine induction system.

In addition to the above-mentioned markings, certain lines may be further identified as to specific function within a system; for example, DRAIN, VENT, PRESSURE, or RETURN.

Lines conveying fuel may be marked FLAM; lines containing toxic materials are marked TOXIC in place of FLAM. Lines containing physically dangerous materials, such as oxygen, nitrogen, or freon, are marked PHDAN.

The aircraft and engine manufacturers are responsible for the original installation of identification markers, but the aviation mechanic is responsible for their replacement when it becomes necessary.

Generally, tapes and decals are placed on both ends of a line and at least once in each compartment through which the line runs. In addition, identification markers are placed immediately adjacent to each valve, regulator, filter, or other accessory within a line. Where paint or tags are used, location requirements are the same as for tapes and decals.

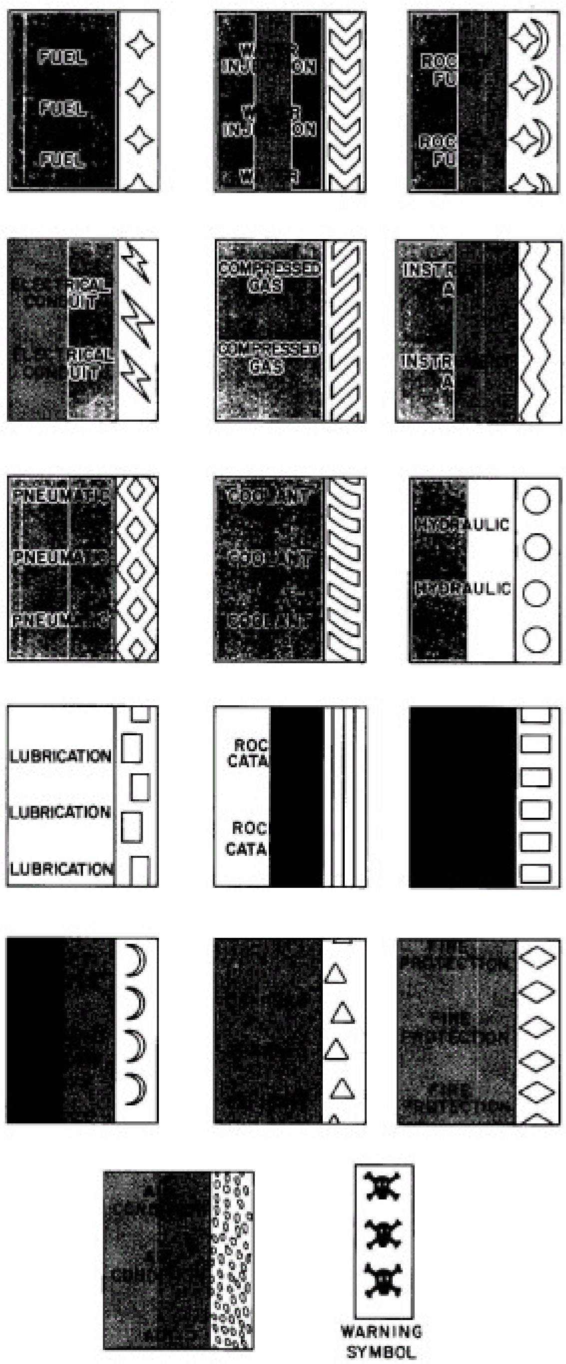


FIGURE 5–3. Identification of aircraft fluid lines.

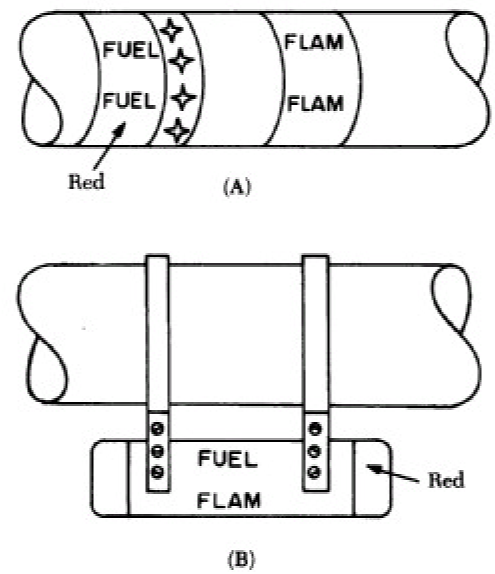


FIGURE 5–4. Fluid line identification using: (A) tape and decals and (B) metal tags.

PLUMBING CONNECTORS

Plumbing connectors, or fittings, attach one piece of tubing to another or to system units. There are four types: (1) Flared fitting, (2) flareless fitting, (3) head and clamp, and (4) swaged. The amount of pressure that the system carries is usually the deciding factor in selecting a connector. The beaded type of joint, which requires a bead and a section of hose and hose clamps, is used only in low- or medium-pressure systems, such as vacuum and coolant systems. The flared, flareless, and swaged types may be used as connectors in all systems, regardless of the pressure.

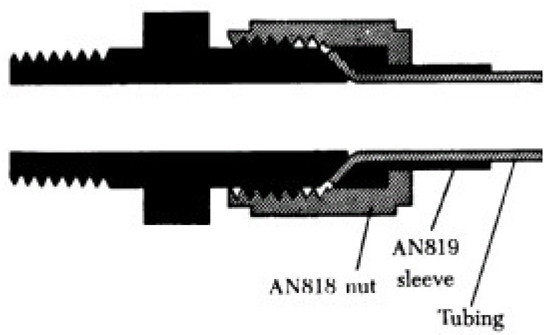


FIGURE 5–5. Flared-tube fitting.

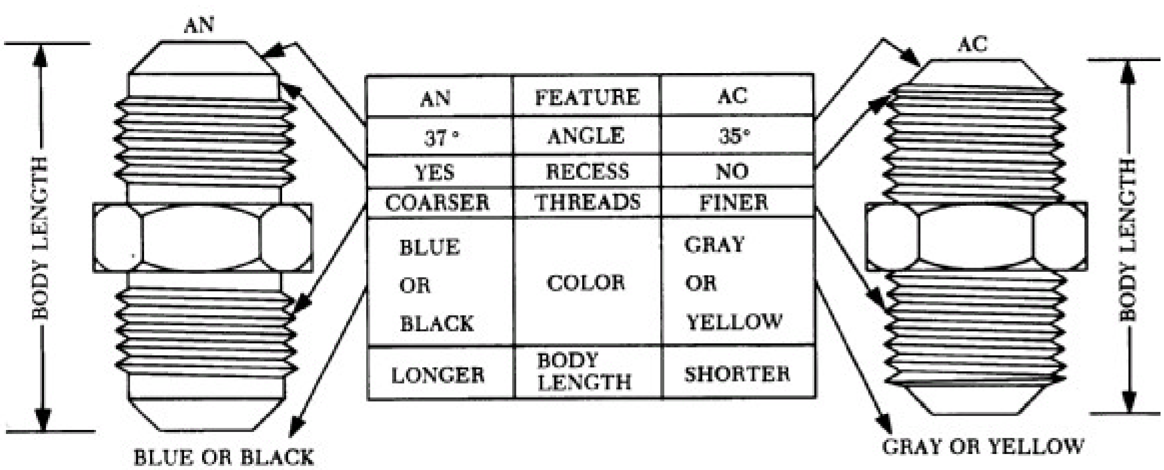


FIGURE 5-6. AN and AC fitting differences.

Flared-Tube Fittings

A flared-tube fitting consists of a sleeve and a nut, as shown in figure 5-5. The nut fits over the sleeve and, when tightened, draws the sleeve and tubing flare tightly against a male fitting to form a seal. Tubing used with this type of fitting must be flared before installation.

The male fitting has a cone-shaped surface with the same angle as the inside of the flare. The sleeve supports the tube so that vibration does not concentrate at the edge of the flare, and distributes the shearing action over a wider area for added strength.

The AC (Air Corps) flared-tube fittings have been replaced by the AN (Army/Navy) Standard and MS (Military standard) fittings. However, since AC fittings are still in use in some of the older aircraft, it is important to be able to identify them. The AN fitting has a shoulder between the end of the threads and the flare cone. The AC fitting does not have this shoulder. Other differences between the AC and AN fittings include the sleeve design, the AC sleeve being noticeably longer than the AN sleeve of the same size. Although certain flared-tube fittings are interchangeable, the pitch of the threads is different in most cases. The figure below AN and AC811 fittings that can be safely interchanged. Combinations of end connections, nuts, sleeves, and tube flares are allowed to make up a complete fitting assembly. The use of dissimilar metals should be avoided since their contact will cause corrosion.

Tube Sizes OD	**Type End Connection (Male Thread)**	**Type Nut (Female Thread)**	**Type Sleeve**	**Type Tube Flare**
All Sizes[1]	**AN**[1]	**AN**[1]	**AN**[1]	**AN**[1]
All Sizes[2]	**811**[2]	**811**[2]	**811**[2]	**811**[2]
All Sizes	**AN**	**AN**	**AN**	**811**
All Sizes	**AN**	**AN**	**811**	**811**
All Sizes	**AN**	**AN**	**811**	**AN**
All Sizes	**811**	**811**	**811**	**AN**
All Sizes	**811**	**811**	**AN**	**AN**
All Sizes	**811**	**811**	**AN**	**811**
1/8, 3/16, 1/4, 5/16, 1 3/4, 2	**AN**	**811**	**AN**	**811**
1/8, 3/16, 1/4, 5/16, 1 3/4, 2	**AN**	**811**	**AN**	**AN**
1/8, 3/16, 1/4, 5/16, 1 3/4, 2	**AN**	**811**	**811**	**AN**
1/8, 3/16, 1/4, 5/16, 1 3/4, 2	**AN**	**811**	**811**	**AN**

1
This is the normal assembly of AN fittings.
2
This is the normal assembly of AC811 fittings.

Figure 5-7a Interchangeability of AN and AC811 fittings.

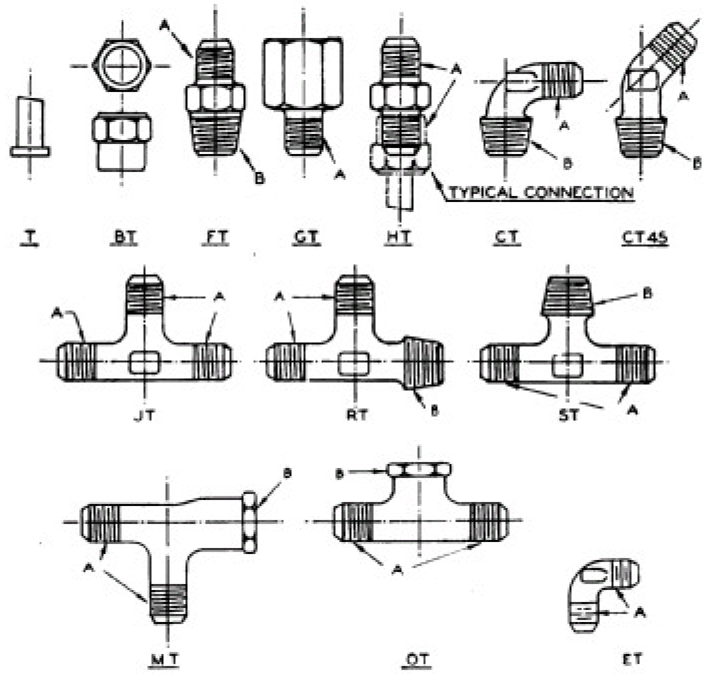


FIGURE 5–7 b. AC811 solderless fittings.

When combining AC and AN end connections, nuts, sleeves, or tube flares, if the nut will not move more than two threads by hand, stop and investigate for possible trouble.

The AN standard fitting is the most commonly used flared-tubing assembly for attaching the tubing to the various fittings required in aircraft plumbing systems. The AN standard fittings include the AN818 nut and AN819 sleeve. (See figure 5-8.) The An819 sleeve is used with the AN818 coupling nut. All these fittings have straight threads, but they have different pitch for the various types.

-- AN744 to AN932 --

Material:

Aluminum alloy .... (code D)
Steel .... (code, absence of letter)
Brass .... (code B)
Aluminum bronze .... (code Z-for AN819 sleeve)

Size:

The dash number following the AN number indicates the size of the tubing (or hose) for which the fitting is made, in 16ths of an inch. This size measures the O. D. of tubing and the I. D. of hose. Fittings having pipe threads are coded by a dash number, indicating the pipe size in 8ths of an inch. The material code letter, as noted above, follows the dash number.

Flared-tube fittings are made of aluminum alloy, steel, or copper base alloys. For identification purposes, all AN steel fittings are colored black, and all AN aluminum alloy fittings are colored blue. The AN 819 aluminum bronze sleeves are cadmium plated and are not colored. The size of these fittings is given in dash numbers, which equal the nominal tube outside diameter (O.D.) in sixteenths of an inch.

Threaded flared-tube fittings have two types of ends, referred to as male and female. The male end of a fitting is externally threaded, whereas the female end of a fitting is internally

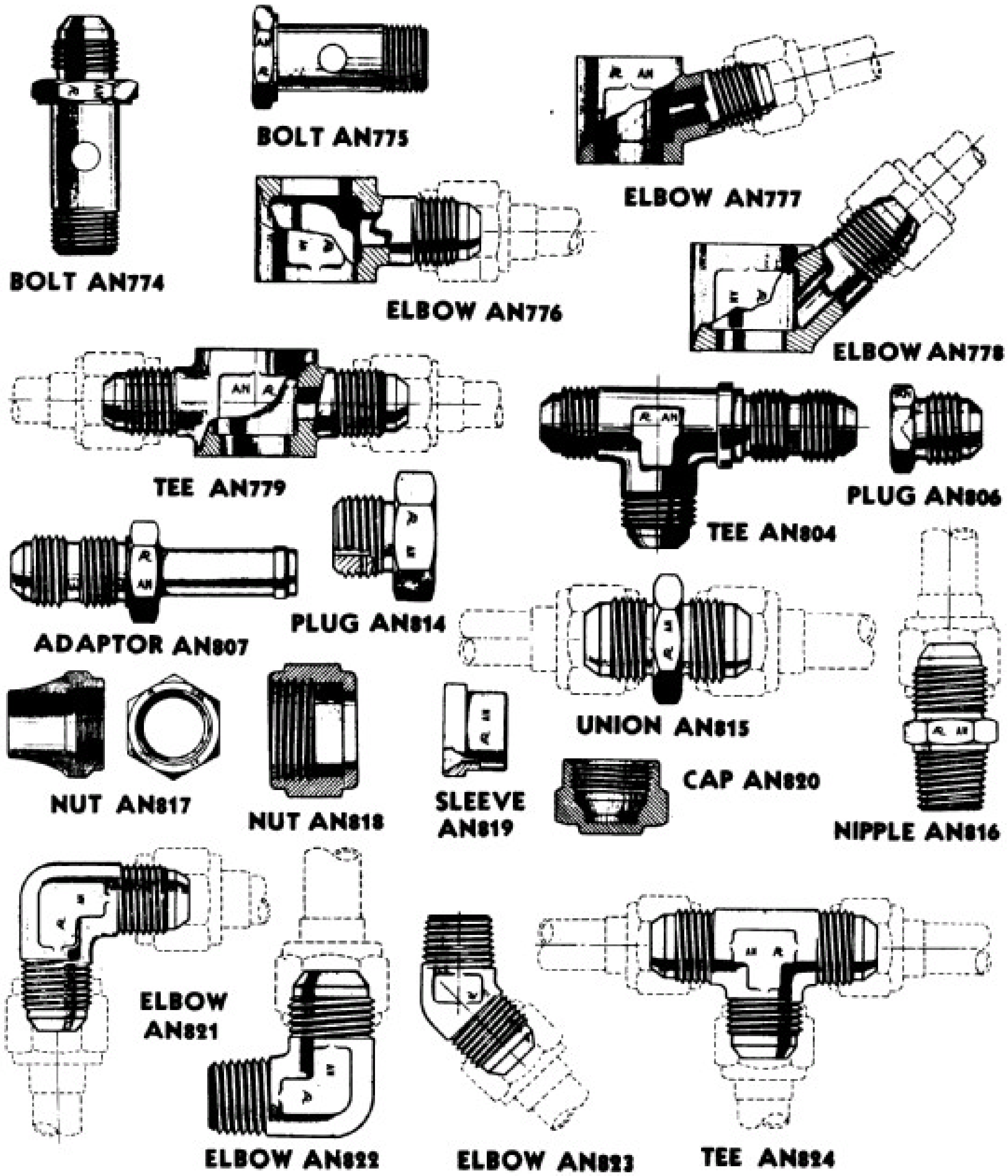


FIGURE 5–8. AN plumbing fittings.

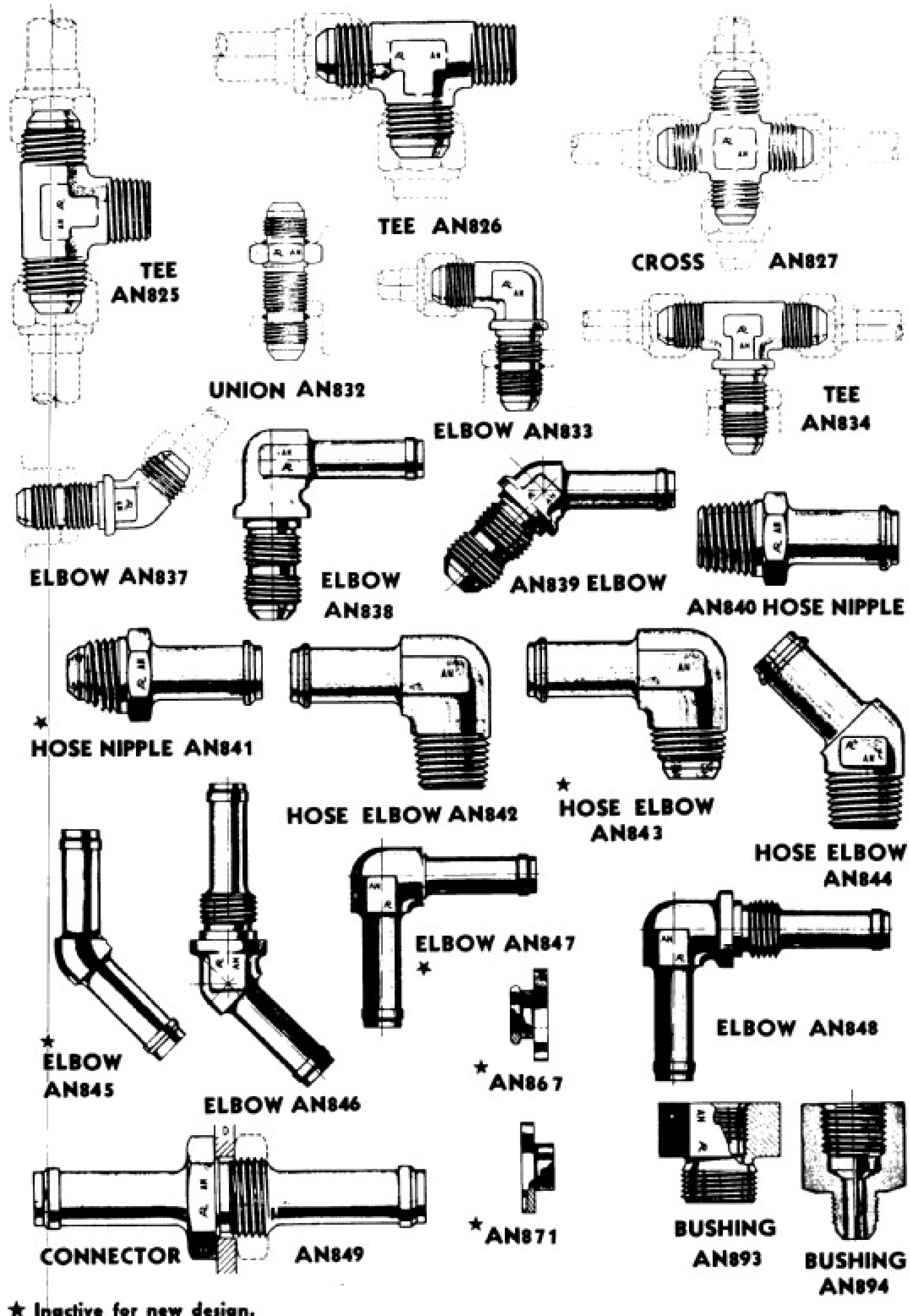


FIGURE 5–8. AN plumbing fittings.—Continued

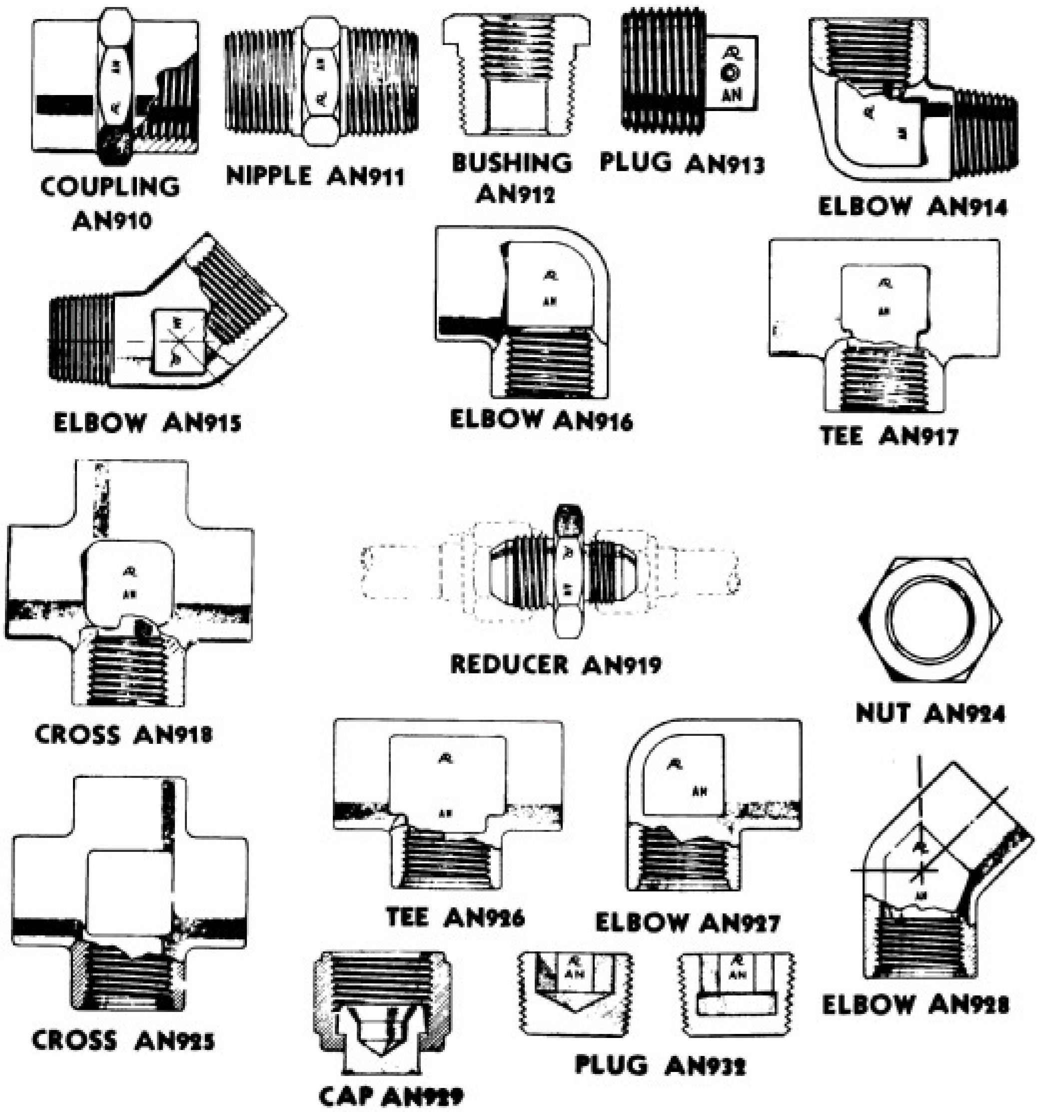


FIGURE 5-8. AN plumbing fittings.—Continued

Threaded.

Flareless-tube Fittings

The MS (Military Standard) flareless-tube fittings are finding wide application in aircraft plumbing systems. Using this type fitting eliminates all tube flaring, yet provides a safe, strong, dependable tube connection. The fitting consists of three parts: a body, a sleeve, and a nut. The body has a counterbored shoulder, against which the end of the tube rests. (See figure 5-9.) The angle of the counterbore causes the cutting edge of the sleeve to cut into the outside of the tube when the two are joined.

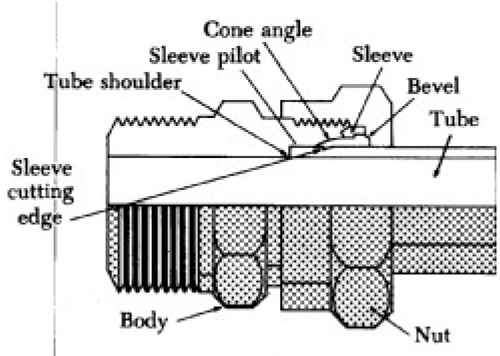


FIGURE 5-9. Flareless-tube fitting.

Quick-disconnect Couplings

Quick-disconnect couplings of the self-sealing type are used at various points in many fluid systems. The couplings are installed at locations where frequent uncoupling of the lines is required for inspection and maintenance.

Quick-disconnect couplings provide a means of quickly disconnecting a line without loss of fluid or entrance of air into the system. Each coupling assembly consists of two halves, held together by a union nut. Each half contains a valve that is held open when the coupling is connected, allowing fluid to flow through the coupling in either direction. When the coupling is disconnected, a spring in each half closes the valve, preventing the loss of fluid and entrance of air.

The union nut has a quick-lead thread which permits connecting or disconnecting the coupling by turning the nut. The amount the nut must be turned varies with different style couplings. One style requires a quarter turn of the union nut to lock or unlock the coupling while another style requires a full turn.

Some couplings require wrench tightening; others are connected and disconnected by hand. The design of some couplings is such that they must be safetied with safety wire. Others do not require lock wiring, the positive locking being assured by the teeth on the locking spring, which engage ratchet teeth on the union nut when the coupling is fully engaged. The lock spring automatically disengages when the union nut is unscrewed. Because of individual differences, all quick disconnects should be installed according to instructions in the aircraft maintenance manual.

Flexible Connectors

Flexible connectors may be equipped with either swaged fittings or detachable fittings, or they may be used with beads and hose clamps. Those equipped with swaged fittings are ordered by correct length from the manufacturer and ordinarily cannot be assembled by the mechanic. They are swaged and tested at the factory and are equipped with standard fittings.

The fittings on detachable connectors can be detached and reused if they are not damaged; otherwise new fittings must be used.The bead and hose clamp connector is often used for connecting oil, coolant, and low-pressure fuel system tubing. The bead, a slightly raised ridge around the tubing or the fitting, gives a good gripping edge that aids in holding the clamp and hose in place. The bead may appear near the end of the metal tubing or on one end of a fitting.

SUPPORT CLAMPS

Support clamps are used to secure the various lines to the airframe or powerplant assemblies. Several types of support clamps are used for this purpose. The rubber-cushioned and plan are the most commonly used clamps. The rubber-cushioned clamp is used to secure lines subject to vibration; the cushioning prevents chafing of the tubing. The plain clamp is used to secure lines in areas not subject to vibration.

A Teflon-cushioned clamp is used in areas where the deteriorating effect of Skydrol (Registered Trademark) 500, hydraulic fluid (MIL-0-5606), or fuel is expected. However, because it is less resilient, it does not provide as good a vibration-damping effect as other cushion materials.

Use bonded clamps to secure metal hydraulic, fuel, and oil lines in place. Unbonded clamps should be used only for securing wiring. Remove any paint or anodizing from the portion of the tube at the bonding clamp location. Make certain that clamps are of the correct size. Clamps or supporting clips smaller than the outside diameter of the hose may restrict the flow of fluid through the hose.

All plumbing lines must be secured at specified intervals. The maximum distance between supports for rigid fluid tubing is shown below.

-Tube OD (in.)	Distance between supports (in.)	
	Aluminum Alloy	Steel
1/8	9 1/2	11 1/2
3/16	12	14
1/4	13 1/2	16
5/16	15	18
3/8	16 1/2	20
1/2	19	23
5/8	22	25 1/2
3/4	24	27 1/2
1	26 1/2	30

Maximum distance between supports for fluid tubing.